NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	2
Course Coordinator	Dr. Charles Wang Wei		
Course Code	CB4001		
Course Title	Microfluidics & Its Applications (Elective)		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	33 hours lecture, 6 hours tutorial		
Proposal Date	5 Oct 2021		

Course Aims

This course aims to provide students the fundamentals of microfluidic and Lab-On-Chip technology, including the basic fluid mechanics theory, microfabrication for microfluidics, microfluidic flow control and system development. Function of microfluidics components, such as valves, pumps and mixers will be explained in details. Applications of microfluidics and Lab-On-Chip will be highlighted by introducing the microfluidic components for life sciences, chemistry, point-of-care diagnostics, Organ-on-Chip and so on. Examples of emerging commercial microfluidic products (i.e. diagnostics cartridge, DNA amplification platforms) will be introduced during the course. Detailed case studies about microfluidic product development will be given on the development for disease diagnosis, prognosis, precision therapy, environment monitoring and so on. Through assignment, students will have the chance to research a particular type of microfluidic technology and its utility for specific applications;

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

1. Understand microfluidics technology and lab-on-a-chip systems
2. Master basic fluid mechanics at small scales
3. Know basic multi-physics for microfluidic applications
4. Apply standard fabrication technologies for microfluidics
5. Know advanced fabrication technologies for microfluidics
6. Master fundamentals of microfabrication techniques and explain the concept of chip design
7. Apply microfluidic components for life sciences and chemistry
8. Describe microfluidic applications with examples for diagnostics/therapy/ synthesis
9. Describe fabrication of polymer microfluidic chips
10. Know microfluidic technology in point-of-care test (POCT) diagnosis (including landscape in Singapore)
11. Explain basic microfluidic product development
12. Presentation of Group Study/Report
13. Presentation of Group Study/Report

Course Content

This course covers basic microfluidic and Lab-On-Chip knowledge, including the fluid mechanics theory, microfabrication for microfluidics, microfluidic flow control and system development. Students will be equipped with the relevant knowledge on a wide range of application areas

including environmental sensing, medical diagnostics, drug discovery, drug delivery, microscale chemical production, combinatorial synthesis and assays, artificial organs, and microscale energy systems.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team /Individual	Assessment rubrics
1. Continuous assessment 1 (Quiz)	1,2,3,4,5	EAB SLOs a, b, d, f, j	20%	Individual	Refer to appendix 1
2. Continuous assessment 2 (Individual case study with report submission)	1,2,3,4,5, 6,7,8,9	EAB SLOs a, b, c, d, f, j,	30%	Individual	Refer to appendix 2
3. Group Assignment (Report & presentation)	1,2,3,4,5, 6,7,8,9,10,11,12	EAB SLOs a, b, c, d, f, i, j, l	50%	Team	Refer to appendix 3
Total			100%		

Mapping of Course ILOs to EAB Graduate Attributes

Course Intended Learning Outcomes	Cat	EAB's 12 Graduate Attributes*										
		(a)	(b)	(c)	(d)	(e)	(f)	(g	(h)	(i)	(j)	(k)
	Elect	●	◐	◐	š		š		š		◐	
Introduction of microfluidics technology and lab-on-a-chip systems											a, f, j	
Explain fluid mechanics at small scales											a, b, d	
Elaborate multi-physics for microfluidic applications											a, b, d	
Illustrate standard fabrication technologies for microfluidics											a, b, d	
Illustrate advanced fabrication technologies for microfluidics											a, b, d	
Apply various microfluidic components for life sciences and chemistry – part 1											a, b, c, j	
Apply various microfluidic components for life sciences and chemistry – part 2											a, b, c, j	
Demonstrate microfluidic applications with examples – Diagnostics/therapy/ synthesis											a, d, i	
Illustrate fabrication of polymer microfluidic chips with case study											a, b, j	

Apply microfluidic technology in point-of-care test (POCT) diagnosis (including landscape in Singapore)	a, b, j
Microfluidic product development with case study	a, b, c, i

Legend: ● Fully consistent (contributes to more than 75% of Intended Learning Outcomes)
◐ Partially consistent (contributes to about 50% of Intended Learning Outcomes)
š Weakly consistent (contributes to about 25% of Intended Learning Outcomes)
Blank Not related to Student Learning Outcomes

Formative feedback

Examination results;
Marker's report on overall examination performance;
Quiz answers will be discussed in class

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lecture	Demonstrate how to carry out a procedure such as working through a problem, use incomplete handouts which enabling students participating in class and practicing to resolve real cases.
Tutorial	Presentation of group study/report followed by discussion on selected topics

Reading and References

1. Fundamental of Microfabrication (Marc Madou, CRC Press, 2nd edition);
2. Fundamentals and Applications of Microfluidics (Nam-Trung Nguyen and Steve Wereley, Artech House)
3. Dongqing Li, Encyclopedia of Microfluidics and Nanofluidics, Springer, 2008.

Course Policies and Student Responsibilities

General: Students are expected to complete all online activities and take all scheduled assignments/tests by due dates. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements. Students are expected to participate in all tutorial/discussions/activities.

Continuous assessments: Students are required to attend all continuous assessments.
Absenteeism: Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Charles Wang Wei	NA	8518 3085	charles.wang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction of microfluidics technology and lab-on-a-chip systems	1	Face to face lecture
2	Explain fluid mechanics at small scales	2	Face to face lecture
3	Elaborate multi-physics for microfluidic applications	3	Face to face lecture
4	Illustrate standard fabrication technologies for microfluidics	3	Face to face lecture
5	Illustrate advanced fabrication technologies for microfluidics	5	Face to face lecture
6	Master fundamentals of microfabrication techniques and explain the concept of chip design	6	Face to face lecture + Quiz
7	Apply various microfluidic components for life sciences and chemistry – part 1	7	Face to face lecture
8	Apply various microfluidic components for life sciences and chemistry – part 2	8	Face to face lecture
9	Demonstrate microfluidic applications with examples – Diagnostics/therapy/ synthesis	9	Face to face lecture
10	Illustrate fabrication of polymer microfluidic chips with case study	10	Face to face lecture
11	Apply microfluidic technology in point-of-care test (POCT) diagnosis (including landscape in Singapore)	11	Face to face lecture
12	Microfluidic product development with case study – part 1	12	Tutorial 1
13	Microfluidic product development with case study – part 2	13	Tutorial 2

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90 %
Knowledge Understanding of principles of microfluidic technology	• Lacks understanding of the principles of microfluidic technology. • Unable to apply the principles of microfluidic technology to solve engineering problems.	• Partial understanding of the principles of microfluidic technology. • Can apply the principles of microfluidic technology to solve simple engineering problems.	• Good understanding of the principles of microfluidic technology. • Can apply the principles of microfluidic technology to solve medium level engineering problems	• Good and comprehensive understanding of the principles of microfluidic technology. • Can apply the principles of microfluidic technology to solve engineering problems.	• Very good and comprehensive understanding of the principles of microfluidic technology. • Can apply the principles of microfluidic technology to solve engineering problems.
Evaluation Able to solve numerical problems in basic microfluidics	• Calculations are attempted but are both unsuccessful and are not comprehensive.	• Calculations are attempted but represent only a portion of the calculations required with some comprehensive to solve the problem.	• Calculations attempted are mostly successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and sufficiently comprehensive to solve the problem.	• Calculations attempted are all successful and fully comprehensive to solve the problem; calculations are also presented elegantly

Appendix 2: Assessment Criteria for Individual Case Study with Report Submission

Individual project (e.g. Evaluation of a commercialized microfluidic based Point-of-Care Product)

Assessment of report

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge & Comprehension Understanding of principles of microfluidic technology	• Lack of evidence of research/study and objectives are not clear. • Lacks understanding of the principles of microfluidic technology. • Unable to identify the principles of microfluidic technology to solve engineering problems.	• Objectives are clearly communicate and there is evidence of research /study with acceptable amount of material prepared. • Partial understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve simple engineering problems.	• There is clear statement of topic objective and there is evidence of research /study with appropriate amount of material prepared. • Good understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve medium level engineering problems	• Objectives are well addressed and well linked to concepts/ knowledge from lectures. Appropriate amount of material is prepared well relevant to the overall message. • Good and comprehensive understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve engineering problems.	• There is a clear logical sequence and information flow to the topic objective. Overall good grasp of the subject matter is demonstrated. • Very good and comprehensive understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve engineering problems.
Application Applying microfluidic principles to solve/analyze problems	• Unable to understand microfluidic applications and apply the knowledge to design and optimize microfluidic systems • Examples chosen to support the argument are irrelevant and not persuasive at all.	• Can read and partially understand microfluidic applications and apply the knowledge to design and optimize simple microfluidic systems • Examples chosen to support the argument are partially relevant and persuasive.	• Can read and understand microfluidic applications and apply the knowledge to design and optimize simple microfluidic systems • Examples chosen to support the argument are relevant and partially persuasive.	• Can read and understand microfluidic applications and apply the knowledge to design and optimize medium level microfluidic systems • Examples chosen to support the argument are relevant and persuasive.	• Can read and understand microfluidic applications and apply the knowledge to design and optimize microfluidic systems • Examples chosen to support the argument are very appropriate for a convincing argument

Analysis Able to analyze problems, make reasonable assumptions, and suggest/choose appropriate methods.	• Unable to make reasonable assumptions and judgment according to the nature of the problems, uncertain about drawing any conclusions.	• Can make reasonable assumptions and judgment, but the choice of methods are not appropriate, uncertain about the accuracy of the outcome.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome mostly, but not necessarily the best choice.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome, can draw reasonable conclusions.	• Can make correct assumptions, can choose appropriate methods to solve the problem and draw conclusions. Can identify potential problems and tailor the process accordingly.

Appendix 3: Assessment Criteria for Group Assignment

Group assignment (e.g. Propose development of microfluidic device/system for certain application)

Group assignment (Oral presentation + reporting slides)

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Knowledge & Comprehension Understanding of principles of microfluidic technology	• Lack of evidence of research/study and objectives are not clear. • Lacks understanding of the principles of microfluidic technology. • Unable to identify the principles of microfluidic technology to solve engineering problems.	• Objectives are clearly communicate and there is evidence of research /study with acceptable amount of material prepared. • Partial understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve simple engineering problems.	• There is clear statement of topic and objective and there is evidence of research /study with appropriate amount of material prepared. • Good understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve medium level engineering problems	• Objectives are well addressed and linked to concepts/ knowledge from lectures. Appropriate amount of material is prepared well relevant to the overall message. • Good and comprehensive understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve engineering problems.	• There is a clear logical sequence and information flow to the topic objective. Overall good grasp of the subject matter is demonstrated. • Very good and comprehensive understanding of the principles of microfluidic technology. • Can identify the principles of microfluidic technology to solve engineering problems.
Application Applying microfluidic principles to solve/analyze problems	• Unable to understand microfluidic applications and apply the knowledge to design and optimize microfluidic systems • Examples chosen to support the argument are irrelevant and not persuasive at all	• Can read and partially understand microfluidic applications and apply the knowledge to design and optimize simple microfluidic systems • Examples chosen to support the argument are partially relevant and persuasive	• Can read and understand microfluidic applications and apply the knowledge to design and optimize simple microfluidic systems • Examples chosen to support the argument are relevant and partially persuasive	• Can read and understand microfluidic applications and apply the knowledge to design and optimize medium level microfluidic systems • Examples chosen to support the argument are relevant and persuasive	• Can read and understand microfluidic applications and apply the knowledge to design and optimize microfluidic systems • Examples chosen to support the argument are very appropriate for a convincing argument

Analysis Able to analyze problems, make reasonable assumptions, and suggest/choose appropriate methods.	• Unable to make reasonable assumptions and judgment according to the nature of the problems, uncertain about drawing any conclusions.	• Can make reasonable assumptions and judgment, but the choice of methods are not appropriate, uncertain about the accuracy of the outcome.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome mostly, but not necessarily the best choice.	• Can make reasonable assumptions and judgment, can choose appropriate methods and predict the outcome, can draw reasonable conclusions.	• Can make correct assumptions, can choose appropriate methods to solve the problem and draw conclusions. Can identify potential problems and tailor the process accordingly.
Presentation and Q&A Demonstrate a technically strong understanding of topic and flawless report in presentation	• Topics have not been fully addressed and discussed. Many errors or ambiguities are present.	• Topics have been partially addressed and discussed with solution well proposed. Some errors or ambiguities are present.	• Relevant topics have been addressed. Few development alternatives are discussed. Errors or ambiguities are present. The final development solution is not necessarily adequate.	• Includes several design alternatives. These have been analysed and discussed. A few minor errors or ambiguities are present. The final development solution is adequate.	• Clear and logical description of the development process, including several solutions. These have been correctly analysed, discussed and presented. Good presentation of the final solution

Assessment Criteria for Peer Evaluation:

If you are working as a group with other students for the homework submission, then, each student in the group is required to rate the contribution of other group members. All evaluations are held in confidence so no student will know how other group members rate his/her contribution. You are to evaluate other group members fairly and objectively, bearing in mind the implications for the other members' grades (explained below). It is absolutely essential for you to submit your peer evaluation form to get marks. To factor peer evaluations into the marks for your homework assignment, the following computation will be used:

- If, on average, a student receives a rating of 9 or more, that student receives 100% of the group's grade.
- If, on average, a student receives a rating of less than 9, that student receives a specific percentage of the group's grade to be determined by the formulae below:

An average rating of 8 to < 9 = 90% + (average rating obtained - 8)*10

An average rating of 7 to < 8 = 80% + (average rating obtained - 7)*10

An average rating of 6 to < 7 = 70% + (average rating obtained - 6)*10

An average rating of 5 to < 6 = 60% + (average rating obtained - 5)*10

An average rating of 4 to < 5 = 50% + (average rating obtained - 4)*10

An average rating of 3 to < 4 = 40% + (average rating obtained - 3)*10

An average rating of < 3 will be investigated by your instructor and the student may receive 0% of group grades.

Example 1:

Assume the overall group assignment is 50 marks, and out of 50 your group got 50 marks. A student with an average rating of 9.10 gets 100% of 50 marks, i.e., 50 marks. An average rating of 6.29 means that a student gets 72.9% (or 70%+(6.29-6)*10) of 50 marks, i.e., 36.45 marks.

Example 2:

Assume the overall group assignment is 50 marks, and out of 50 your group got 30 marks. A student with an average rating of 9.10 gets 100% of 30 marks, i.e., 30 marks. An average rating of 6.29 means that a student gets 72.9% (or 70%+(6.29-6)*10) of 30 marks, i.e., 21.87 marks. Your instructor reserves the right to review the student ratings for questionable circumstances, which include, but are not limited to, acts of discrimination or malice.

Criteria	Yourself	Member 1	Member 2	Member 3	Member 4	Member 5
Contributed the fair share of work (Score: 0 to 10)						
TOTAL						
Comments, if any						

Appendix 4: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change